FIREGROUND RADIO COMMUNICATIONS AND FIREFIGHTER SAFETY

EXECUTIVE PLANNING

BY: J. Curtis Varone
Providence Fire Department
Providence, Rhode Island

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ABSTRACT

Concerns over radio channel overloading prompted the Providence Fire Department to obtain additional radio channels to supplement the existing single channel. The problem prompting this research was that the dispatch office was not staffed to monitor the use of additional channels. As a result, concerns were raised about the safety of operational personnel if the additional channels were not monitored by dispatchers.

The purpose of this research was to develop a plan to implement the additional channels. The evaluative research method was used. The research questions were:

1. Is the existing single radio channel used by the Providence Fire Department adequate given the volume of radio traffic that the system is expected to handle?

2. Are there documented cases of firefighters being killed or injured where the fact that radio channels were too busy with other traffic was found to be a contributing factor?

3. Are there documented cases of firefighters being killed or injured where the lack of monitoring of the radio channel by dispatch personnel was found to be a contributing factor?

4. Do most fire departments that use multiple radio channels have dispatchers monitor all channels being used?

5. What procedures do fire departments that use unmonitored fireground channels use so that critical messages are properly transmitted, received, acknowledged and acted upon?

The literature review found nationally accepted recommendations for fire communication systems and identified cases of communications-related firefighter casualties. Two surveys were conducted: one of fire officers in Providence to document the extent of overloading problems, and the other of various fire departments to obtain information regarding overloading problems and multichannel operations.

The results showed that the single-channel system in Providence was dangerously overloaded. Documented cases of firefighter casualties associated with both radio channel overloading and lack of monitoring by dispatchers were identified in other departments. Most fire departments surveyed required dispatchers to monitor fireground channels. Of the departments that did not have dispatchers monitor fireground channels, a variety of steps were taken to minimize the risk to operational personnel.

Recommendations included implementing a multichannel radio system in Providence; ensuring that all tactical channels be dispatcher monitored whenever in use; providing training for dispatchers and line personnel; protective equipment modifications; development of a portable radio specifically for firefighters; updating NFPA standards to address communications-related safety issues; and additional research into the firefighter safety aspects of radio communications.

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INTRODUCTION

Between 1989 and 1995, the Providence Fire Department responded to over 36,000 incidents annually. All radio communications within the Department took place over a single radio channel. This included the dispatching of alarms, the relay of pertinent response related information from dispatchers to responding apparatus, incident scene communications between companies and dispatchers, unit to unit communications on the scene, and routine radio traffic (J.R. Richardson, personal communication, October 30, 1995).

In response to concerns that the single radio channel was being overwhelmed, the Department obtained four additional radio channels for use as fireground tactical channels. These channels were obtained with the intention of alleviating radio congestion and improving operational efficiency (J.R. Richardson, personal communication, October 30, 1995).

The problem prompting this research was that the dispatch office, known as the Bureau of Operational Control (BOC), was staffed for operations based upon the use of the single, primary radio channel. Not enough personnel were assigned to ensure that a dispatcher would always be available specifically to monitor the use of even one additional fireground tactical channel.

As a result, the Chief of Department, the Department Safety Officer, and the firefighters' union expressed concerns about the safety of operating personnel if the fireground tactical channels were not monitored. These concerns centered upon the fact that emergency messages from firefighters in distress may be missed if the radio channel being used was not monitored by dispatch personnel (J.R. Richardson, personal communication, October 30, 1995).

The purpose of this research was to develop a plan for implementing the use of the fireground tactical channels by the Providence Fire Department. The evaluative research method was used. The following research questions were posed:

1. Is the existing single radio channel used by the Providence Fire Department adequate given the volume of radio traffic that the system is expected to handle?

2. Are there documented cases of firefighters being killed or injured where the fact that radio channels were too busy with other traffic was found to be a contributing factor?

3. Are there documented cases of firefighters being killed or injured where the lack of monitoring of the radio channel by dispatch personnel was found to be a contributing factor?

4. Do most fire departments that use multiple radio channels have dispatchers monitor all fireground channels that are being used?

5. What procedures do fire departments that use unmonitored fireground tactical channels use so that critical messages (particularly "Mayday" messages or building evacuation orders) are properly transmitted, received, acknowledged and acted upon?

BACKGROUND AND SIGNIFICANCE

Providence Fire Department

The City of Providence is the capital of Rhode Island, covering an area of approximately 20.5 square miles. The resident population of Providence has dropped from a post-World War II high of 250,000 in 1950, to approximately 160,000 in 1990 (Polk & Company, 1993). The result was a large number of vacant buildings, a high number of vacant building fires, and a declining tax base (Conley & Campbell, 1985). Nevertheless, the average daily work-day population in Providence for 1995 was estimated at over 260,000 (A. Quinterno, personal communication, February 7, 1996).

In 1995, the Providence Fire Department operated 15 engine companies, 8 ladder companies, 5 advanced life-support rescue companies (ambulances) and 3 on-duty chief officers. The authorized strength of the Department was 539 uniformed members. Operational personnel were assigned to a four-platoon rotating schedule. Minimum shift staffing was 98 members per shift.

The Providence Fire Department is a division within the City of Providence Department of Public Safety. The Fire Chief reports to the Commissioner of Public Safety, who in turn reports directly to the mayor. The Commissioner of Public Safety oversees the operations of the Providence Fire Department, Providence Police Department, Providence Department of Communications, and the Providence Emergency Management Agency.

Providence Department of Communications

In 1970, the Fire Alarm Division of the Providence Fire Department was reorganized and a new City department, called the Department of Communications, was created to serve as a separate division within the Providence Department of Public Safety (J.R. Richardson, personal communication, November 28, 1995). The Department of Communications assumed responsibility for all radio and telecommunications within City government, including police communications and teletype, fire alarm and fire communications, public works radio, water department radio, telephone service, and all City computer networks.

Within the Department of Communications, the BOC was responsible for receiving fire and emergency medical related telephone calls and fire (box) alarms, dispatching apparatus, maintaining communications with apparatus engaged at the scene of emergencies, providing support to onscene units, and handling routine radio traffic from units on the air. BOC's normal staffing was one fire lieutenant (supervisor) and two civilian dispatchers.

BOC dispatched apparatus simultaneously over a "Voc-Alarm" system and over the primary radio channel. The Voc-Alarm system was a hard-wired system connected to speakers and alerting devices in each fire station. Communications over the Voc-Alarm were one way, from BOC to the stations.

All radio communications on the primary radio channel, whether routine or emergency, were monitored and controlled by BOC. BOC dispatchers served to maintain control of the radio network, prioritize messages, and relay information from one unit to another, ensuring that an acknowledgment was received.

During emergency scene operations, the support provided by BOC went beyond monitoring and controlling the radio channel. Upon request of an Incident Commander (IC), BOC dispatchers made emergency notifications, building evacuation orders, and even conducted emergency roll-calls to account for the location and safety of operational personnel.

Radio Communications

Communications have always played a critical role in the efficient management of fireground operations (Spahn, 1989). From the traditional fire chief's "trumpet," to modern high-tech radio systems, the communication of instructions and the flow of information up and down the chain of command has been essential to effective fireground operations (New Jersey Bureau of Fire Safety, 1988).

Prior to the use of radios in the fire service, many chief officers believed that the only place they could effectively control fireground operations was inside the building with personnel attacking the fire, or at least within shouting distance of them (A.F. Bertoncini, personal communication, January 12, 1996). Under such a system, freelancing on the fireground was not only tolerated, it was institutionally encouraged and rewarded. Because of the difficulty in communicating and the fact that the chief could not be everywhere at once, freelancing was accepted as a necessary evil (A.F. Bertoncini, personal communication, January 12, 1996).

Electronic radio communications first entered the fire service in the 1940s by way of apparatus-based two-way mobile radios (Spahn, 1989). While the addition of radios in apparatus greatly improved the ability of operating forces to communicate with the dispatch center, fireground operations remained virtually unchanged, and were still based

in large measure upon face-to-face communications, hand signals, and a lot of guess work (A.F. Bertoncini, personal communication, January 12, 1996).

In the 1960s and 1970s, technological advances made portable radios feasible for use in the fire service (Spahn, 1989). Portable radios offered to dramatically increase the flow of information from the company level to the command level. This, in turn, lessened the need for the chief to be just behind the nozzleman. The chief could remain outside the fire building, and rely upon company officers to relay pertinent information. Fireground operational activities could be coordinated effectively from a remote location to an extent never before possible.

The widespread use of portable radios increased the number of radios on the typical fire scene, and led to a dramatic increase in the amount of radio communications taking place. The increased use of radio airwaves led to the need for additional radio frequencies (J.R. Richardson, personal communication, November 28, 1995).

In Providence, the first portable radios appeared in 1969, and were assigned to chief officers (J.R. Richardson, personal communication, November 28, 1995). In 1974, portable radios were issued to rescue companies, followed shortly thereafter by engine and ladder companies in 1975.

The issuance of portable radios in Providence resulted in an explosive increase in the volume of radio traffic (J.R. Richardson, personal communication, November 28, 1995). At the same time, there was a dramatic increase in the fire department's overall reliance upon radio communications (A.F. Bertoncini, personal communication, January 12, 1996).

By 1980, communication problems prompted the Providence Fire Department and the Providence Department of Communications to change the primary radio channel from a simplex to a duplex system (J.R. Richardson, personal communication, November 28, 1995). The principal reason for this change was to improve the reception of radio traffic from portable radios in certain areas of the City. Hand-held portable radios were considerably less powerful than the mobile radios installed in apparatus, and thus their signal did not carry as far as the mobile radios. The duplex system facilitated the use of two receiver sites instead of just one, thereby significantly improving the ability of BOC and other units to receive messages from portable radios.

In 1994, concerns over communications from portable radios prompted the Department of Communications to increase the number of receiver sites in the City from two to six (J.R. Richardson, personal communication, November 28, 1995). The additional receiver sites were intended to ensure that dispatchers at BOC would be able to hear a portable radio transmission made from any part of the City.

The widespread use of portable radios by the fire service has improved the operational efficiency of fire departments while at the same time improving the safety and accountability of firefighters (A.F. Bertoncini, personal communication, January 12,

1996). However, not so surprisingly, along with the increased reliance upon radio communications has come an increased number of situations where a breakdown in fireground communications has been implicated in firefighter deaths and injuries.

This paper was prepared to satisfy the applied research requirements associated with the *Executive Planning* course at the National Fire Academy (NFA). This research relates to the analysis unit of the *Executive Planning* course by obtaining, summarizing and analyzing data to make accurate assessments and facilitate decisionmaking.

The results of this research have tremendous significance to the Providence Fire Department and the Providence Department of Communications in terms of how fireground tactical radio channels will be incorporated into the Providence Fire Department. This research provides facts and recommendations that will assist the Fire and Communications Departments in deciding how best to implement the necessary changes associated with using fireground tactical radio channels. This research may also be significant to other fire departments in regards to understanding the firefighter safety implications of radio channels that are not monitored by trained dispatchers.

LITERATURE REVIEW

National Standards and Recommendations

The literature review identified several National Fire Protection Association (NFPA) standards that addressed radio communications in the fire service. NFPA Standard Number 1500, 1992 Edition, entitled "Standard on Fire Department Occupational Safety and Health Program," stated in Chapter 6-1.6 that "The fire department shall establish and ensure the maintenance of a fire dispatch and incident communication system that meets the requirements of Section 3-6 of NFPA 1561, "Standard for Fire Department Incident Management System" (NFPA 1500, 1992, p. 20).

NFPA 1561, "Standard for Fire Department Incident Management System," 1990 Edition, addressed communications in Chapter 3-6. Chapter 3-6.4 required that communication systems follow a standardized method of transmitting emergency messages and notifications of imminent hazards to all levels of the command structure at emergency scenes. Chapter 3-6.5 required the fire department to establish standard operating procedures (SOPs) for communications "operators" and "dispatchers" to "provide support to emergency incident operations" (NFPA 1561, 1990, p. 8). The terms "operator," "dispatcher," and "provide support to" were not further defined.

NFPA Standard Number 1201, 1994 Edition, "Standard for Developing Fire Protection Services for the Public," addressed fire service communications comprehensively in Chapter 16. Fire departments must provide a "reliable communications system" that complies with NFPA 1221 (NFPA 1201, 1994, p. 16). All field units available for dispatch to emergencies must be radio equipped and capable of constant communications with dispatchers (NFPA 1201, 1994, p.17). All chief officers

and company officers must be provided with a portable radio while assigned to emergency duty (NFPA 1201, 1994, p. 17).

Chapter 16-5.3 of NFPA 1201 stated that "Sufficient radio frequencies shall be provided to accommodate the operational needs of the fire department...based upon the amount of radio traffic that is anticipated...." (NFPA 1201, 1994, p. 17).

NFPA 1221, "Standard for the Maintenance and Use of Public Fire Service Communication Systems," 1994 Edition, further identified the components of a safe, efficient and reliable communications system. Chapter 3-6.3 stated that "A separate frequency shall be provided for fire ground communications for jurisdictions or multiple jurisdictions on the same channel receiving 2500 or more alarms per year or where multiple jurisdictions share a common radio frequency" (NFPA 1221, 1994, p. 20). Chapter 3-4.1.5 stated that "Radio dispatch channels shall be separate from radio channels used for routine or fireground communications" (NFPA 1221, 1994, p. 19).

NFPA 1221 also addressed the subject of communications office staffing. Chapter 2-1.8.1 stated that communications centers handling more that 600 alarms per year shall have a sufficient number of operators to

> affect the prompt receipt and processing of and request for fire department services as follows: (1) Ninety-five percent of alarms shall be answered within 30 seconds, and in no case shall the initial operator response to an alarm exceed 60 seconds. (2) The dispatch of the appropriate fire services shall be made within 60 seconds after completed receipt of an emergency alarm (NFPA 1221, 1994, p. 8).

Supervisory personnel assigned to the communications center would be over and above these requirements.

The performance-based staffing requirements of the 1994 Edition of NFPA 1221 were a departure from the 1991 Edition, which required a minimum of two dispatchers to be on duty for jurisdictions handling more than 600 responses, plus one additional operator per 20 incoming alarms per hour, plus an operator for transmitting alarms to stations, plus an operator for the tactical radio channels, plus supervisory personnel (NFPA 1221, 1991).

Collectively, the NFPA standards influenced this research by providing a comprehensive and integrated framework for the operational requirements of an effective radio communications system.

Two major publications were also found that addressed radio communications in the fire service. Holt, in 1991, wrote a book addressing the management of fire communications systems. Holt acknowledged the critical role that dispatchers play in regards to firefighter safety. He emphasized the need for improved dispatcher selection and training as critical elements of an effective emergency communications system. Holt

recommended detailed operating procedures and specific training to help dispatchers maintain control of the radio network during critical phases of emergency incidents.

In 1989, Spahn wrote a book on fire service radio systems. Spahn's book focused primarily upon the hardware and technological aspects of radio communications. However, he did state that monitoring incident-related communications was an important function of dispatchers.

> While units are committed to incidents, the [dispatch] office must be alert to aid units in communicating with each other. Often the noise level associated with the operation of heavy firefighting equipment makes it difficult for other personnel in the field to hear another unit or person calling on the radio. It is the duty of dispatch to facilitate these communications. **Often dispatchers have been the only individuals capable of hearing a feeble cry for help from a portable unit** [emphasis added] (Spahn, 1989, p.18).

The writings of Holt and Spahn influenced this research by providing historical and background information on fire department communication systems. These books were the only major works found that focused on fire service radio communications. It was notable that neither author specifically recommended or discussed the need for fireground channels to be monitored by dispatch personnel.

Firefighter Casualties Related to Communications

A literature review was also conducted to attempt to identify documented cases where firefighters have been killed or injured under circumstances where a radio communications failure was found to be a contributing factor.

The earliest documented case where radio communications was implicated in a firefighter casualty was in Syracuse, New York, in 1978 (Demers, 1978). Four firefighters died in a three-story wood-frame apartment building when fire erupted out of a void space, trapping them on the third floor.

Approximately 16 minutes into the fire a weak radio transmission, "Help me," was recorded on the "Master Fire Control Tape" at the Syracuse Fire Department dispatch office (Demers, 1978, p. 24). There was no indication that anyone on the fireground or in the dispatch office heard the message. Approximately one minute later, a second transmission was recorded: "Help, help, help, static" (Demers, 1978, p. 24). This transmission was apparently not heard by any fire personnel on the scene or in the dispatch office. However, an observer with a scanner reported to a fire officer on the scene that he heard a radio transmission, "Help, help, help, third floor attic" (Demers, 1978, p. 25). It was not clear what action was taken in response to the information provided by the observer, but a second alarm was not called for another 16 minutes (33

minutes into the fire), and the first of the fatalities was not discovered until about 4 minutes after the second alarm was called (37 minutes into the fire).

Among the most well-documented cases of a communications failure contributing to firefighter fatalities, was the July 1, 1988, fire at Hackensack Ford in Hackensack, New Jersey. In 1988, Klem wrote the NFPA investigative report on the Hackensack fire, detailing the circumstances that led to the deaths of five firefighters when a bow-string truss roof collapsed at a fire in an auto dealership.

Approximately one minute before the roof collapsed, the IC ordered over the radio for companies operating on the interior to "back your lines out" (Klem, 1988, p. 43). This message was not acknowledged by any of the companies operating on the interior of the building, nor was it acknowledged and/or repeated by the dispatch center. When the collapse occurred, three firefighters in the building were pinned by falling debris. Two other firefighters were able to escape into an adjacent tool room.

Approximately three minutes after the roof collapsed, radio calls for help were made by the two trapped firefighters who escaped into the tool room. These calls initially went unanswered by either the IC or the fire alarm dispatcher. However, the calls were heard clearly by civilians with scanners who were monitoring the incident and were recorded on the dispatch office's tape recorder. Some listeners even called the dispatch center on the telephone to inform the dispatcher of the trapped firefighters. By the time the IC became aware of the calls for help, an effective rescue effort could not be mounted to save the trapped members.

In 1988, Demers wrote about the Hackensack fire, concluding that a "major contributing factor" resulting in the firefighter deaths was the "lack of effective fireground communications both on the fireground and between fireground commanders and fire headquarters..." (Demers, 1988, p. 1). Demers analyzed the sequence of communications made by the trapped firefighters, which extended over a 15 minute and 50 second period.

Among the points Demers made was that Hackensack's single radio channel was inadequate to perform all the functions expected of it, including dispatching apparatus, fireground operations, recall of off-duty personnel, and emergency medical calls. Demers cited numerous times when the dispatcher "over-rode" the radio transmissions of fireground units, including urgent requests for help by the trapped firefighters (Demers, 1988, p. 15).

The New Jersey Bureau of Fire Safety (1989), also investigated the Hackensack fire, and like the other investigators cited major communications problems as a contributing factor in the firefighter deaths. The Bureau audited the radio communications tape and discovered that approximately 50 percent of all radio communications made at the Hackensack Ford fire, were never acknowledged. The Bureau recommended that all fire departments in the State of New Jersey establish a

minimum of two separate radio channels so as to permit the dispatching function to take place on a channel other than the one being used for fireground communications.

The Memphis Fire Department witnessed two recent fires where communications problems played a role in firefighter fatalities. Smith (1993), wrote about an internal investigation by the Memphis Fire Department into a church fire that occurred on December 26, 1992, in which a wood-truss roof collapsed killing two firefighters. Crews at the scene were operating on a fireground channel that was not being monitored by dispatch personnel.

Upon arrival, a Battalion Commander attempted to contact first-in units by radio, but was unable to do so after repeated attempts. The Commander, believing his portable radio to be malfunctioning, physically went to check on the progress of companies. The collapse occurred shortly thereafter. When the collapse occurred, the Commander again attempted to contact other units on the scene to advise them of the situation, and again received no response.

Among the recommendations of the investigation team were better training of company officers and acting company officers in incident command, an increased emphasis on fireground communications, the recording of fireground communications by the dispatch office, and the dispatch of additional command personnel to working fires in commercial occupancies or large structures.

Routley (1992), investigated the Memphis church fire for the United States Fire Administration (USFA). Routley also found that communications problems contributed to the firefighter deaths, concluding that the Battalion Commander was unable to direct operations on the fireground channel. Routley cited the fact that fireground radio channels in Memphis are neither repeated nor monitored by the communications center, as one problem area. Apparently, the failure of some company officers and acting officers to monitor the radio and/or hear the radio over ambient noise, also contributed to the communications difficulties.

In 1995, Chubb and Caldwell wrote about the April 11, 1994, fire at the Regis Tower in Memphis, at which two firefighters died. The fire occurred on the ninth floor of an eleven story fire-resistive highrise building. The first firefighters to arrive on the fire floor were quickly in peril for a number of reasons, including a decision to take the elevator to the fire floor, an hysterical and violent male victim, and the occurrence of a flashover in the room of origin.

Companies on the scene were operating on an unrepeated fireground channel. At one point a firefighter (who was later to die) made a series of four urgent radio transmissions attempting to communicate with his company officer. These transmissions were apparently made inadvertently on the dispatch channel, not the fireground channel.

The IC was monitoring the fireground channel using his portable radio, while at the same time attempting to monitor the main dispatch channel using the mobile radio in

his vehicle that was serving as the Command Post. At the time these urgent transmissions were made, the IC was away from his vehicle, and thus he did not hear them. The transmissions were heard by a dispatcher monitoring the dispatch frequency, but no further action was taken by the dispatcher to inform the IC that a member may have been in distress.

In 1990, Isner wrote about his investigation of a fire at the Blackstock Lumber facility in Seattle, Washington, on September 9, 1989. The fire claimed the life of a Seattle fire lieutenant. The lieutenant had advanced a handline into an exposure building with another firefighter when conditions rapidly deteriorated. After trying unsuccessfully to find their way out, the officer began calling for help on his portable radio. As the officer got low on air, he passed the radio to the firefighter who also transmitted repeated requests for help. None of these requests for help were heard by the IC, other personnel on the scene, or by dispatch personnel. However, the transmissions were heard by people in the area who were monitoring the incident with scanners.

The firefighter was able to make his way close to an exit where he collapsed and was eventually rescued. At the time the firefighter was rescued, he was incoherent and no one realized that the lieutenant was still in the building. The lieutenant ultimately died of "inhalation of products of combustion" (Isner, 1990, p. 33).

The firefighter subsequently reported that when he was calling for help over the radio he could hear the dispatchers providing "move-up" information to companies that were relocating, so he knew that the radio was working. Isner concluded that the radio was not on the normal fireground channel, since no one at the scene heard the requests for help. He also concluded the radio was not transmitting through the repeater, without which the portable radio could not have been heard by the dispatch center.

In 1993, Routley wrote about a USFA investigation into the deaths of two firefighters in Pittston, Pennsylvania. The firefighters were operating a handline inside a commercial building when the floor collapsed. Routley cited the fact that the interior crew did not have a portable radio with which to communicate with the IC as a contributing factor in the deaths.

Routley (1991a), investigated the East Bay Hills fire in Oakland, California. An Oakland Fire Department Battalion Chief was one of 25 deaths that resulted from this wildland-urban interface fire. Routley found that the communications system being used by the Oakland Fire Department was completely inadequate. Oakland used a single radio channel for both dispatch and emergency operations. Although a backup channel was available to handle all other radio traffic during an emergency, all six alarms at the East Bay Hills fire were operating on the main channel. The result was that units were routinely transmitting over each other, blocking effective communications.

Another communications problem that Routley cited at the East Bay Hills fire occurred when command officers switched momentarily to the backup channel for better communications. The result was that while command officers were communicating on

the backup channel, they missed critical operational information being transmitted on the main channel. Routley concluded:

> Without effective communications, it became an undirected and uncoordinated situation, with companies doing whatever they could to provide for their own safety and evacuate residents in the path of the fire. It was during this period that the Battalion Chief was lost....The radio tape indicates that he may have tried unsuccessfully to communicate as late as 1222 hours, approximately 30 minutes after his last successful communication [with the Operations Chief] (Routley, 1991a, p. 76).

Routley (1991b), also investigated a fire in Brackenridge, Pennsylvania, in which four firefighters were killed when a floor collapsed. Communications problems were again implicated. Several communities shared a common primary radio channel, which became overloaded with incident-related communications, dispatch tones and other routine traffic. Because of the heavy traffic, one of the mutual-aid units decided to switch to a tactical channel, essentially cutting themselves off from communications with the IC and others operating at the scene. This unit, which was operating a handline inside the fire building, was unaware of reports coming from other units at the scene that could have warned them that a dangerous situation was developing.

Routley concluded that as a general safety rule "It is extremely important [for an incident commander] to maintain communications with all units on the fireground, particularly units assigned to interior positions.... All tactical communications must be monitored by designated individuals in the command structure" (Routley, 1991b, p. 24). Routley also cited the dual function police-fire dispatchers as inadequate to effectively manage a major incident.

Chubb (1992), investigated a fire that occurred at the Indianapolis Athletic Club in Indianapolis, Indiana, on February 5, 1992. Two firefighters were killed and four seriously injured after fire erupted from a concealed space. Chubb cited a number of communications-related factors as having an impact on the outcome of the fire. The first was the fact that Indianapolis had implemented a new 800 MHz trunked radio system two weeks before the fire. Lack of familiarity with the system by all members contributed to the communications-related problems observed during the fire.

Second, a fire captain was seriously burned when he removed his glove to activate the emergency-distress alarm on his portable radio. Chubb concluded that the button for the emergency-distress alarm was virtually impossible to activate with a gloved hand, particularly given the fact that radios must be concealed in pockets or under protective clothing to protect them from the hazards of firefighting. The captain also attempted to verbally request assistance using his portable radio, but these attempts were unsuccessful.

Third, the IC's request for a second alarm was delayed while another alarm was dispatched. Then, after the second alarm request was received, there was a seven-minute

delay in processing it. Chubb attributed this delay to lack of familiarity with the new computer-aided dispatch system and/or new procedures.

In 1995, the Bureau of Land Management (BLM) investigated a wildland fire that took the lives of two firefighters in Kuna, Idaho. The investigation team cited the lack of adequate communications as a significant factor in the deaths. The dead firefighters had been operating in the path of a rapidly moving fire. Their radio was not equipped to communicate with the IC, and the IC as well as other officers on the scene were unable to warn them of the approaching peril.

In 1991, Rosato wrote about the June 25, 1990, wildland fire in Tonto, Arizona, where a communications breakdown was cited as a major factor in the deaths of six firefighters. Fire crews from different agencies operated on their own frequencies, and could not communicate with each other. In some cases, fire crews could not even communicate with their supervisors. The lack of coordination, and the fact that there was not a single frequency that all crews could communicate on, contributed to 11 firefighters being trapped in a canyon, 6 of whom died.

Finally, Routley (1995), investigated the February 14, 1995 fire in Pittsburgh, Pennsylvania, that claimed the lives of three firefighters. During a critical period in the fire, four firefighters ran out of air and became disoriented in the building. One firefighter was located and removed by other personnel. Although only semiconscious the rescued firefighter reported that other members were still inside.

Over the next few minutes, confusion developed as to how many firefighters were actually missing, and how many had been rescued. The confusion led to the erroneous conclusion that all members were accounted for, when in fact the three firefighters were still lost in the building.

Routley cited communications problems as a contributing factor in the failure to realize that three members were still missing. Pittsburgh's fire department and emergency medical services were separate municipal departments that routinely responded to fires together. Each department operated on entirely separate radio channels. Direct radio communications between emergency medical personnel and the fire department IC was not possible. This arrangement contributed to the confusion as emergency medical personnel relayed messages through their dispatcher, to the fire dispatcher and ultimately to the IC about who was missing and who had been rescued.

Collectively, the writings of Demers, Klem, the New Jersey Bureau of Fire Safety, Smith, Routley, Chubb and Caldwell, Isner, Chubb, the Bureau of Land Management and Rosato, provided a factual foundation for the linkage of firefighter safety to effective fireground communications, as well as evidence of the converse: the failure of fireground communications has contributed to documented cases of firefighter deaths and injuries. These writings also show the level to which the fire service has come to rely upon radio communications.

PROCEDURES

The research procedure used in preparing this paper began with a literature review at the Learning Resource Center (LRC) at the National Emergency Training Center (NETC) in October of 1995. Additional literature reviews were conducted at the Providence Public Library in Providence, Rhode Island, as well as the author's personal library between October, 1995 and January, 1996.

The literature review focused on two specific areas. First, a search was made for authoritative sources that addressed fire service communications. This search was intended to identify nationally accepted standards or recommendations addressing fire service communications systems. Second, an attempt was made to identify and catalog documented cases of firefighter deaths or injuries where communications problems were implicated.

Interviews were conducted with Kathy Gerstner, a research specialist for the United States Fire Administration, on October 4, 1995; Joseph R. Richardson, Deputy Director of Communications for the City of Providence, on October 30, 1995; and Anne Quinterno, Administrative Assistant to the Mayor of the City of Providence, Vincent A. Cianci, Jr., on February 7, 1996.

Alfred F. Bertoncini, Fire Chief in North Providence, Rhode Island, and a 37-year veteran of the Providence Fire Department, was interviewed on January 12, 1996, to gain a historical perspective on how radio communications have affected fire department operational activities.

Division Chief Richard B. Arwood, of the Memphis Fire Department, was interviewed over the telephone on October 31, 1995, concerning the two Memphis fires cited in the paper. John A. Reardon, a retired Detroit firefighter, was interviewed over the telephone on December 13, 1995, about radio communication problems in the Detroit Fire Department.

David P. Demers, P.E., was interviewed over the telephone on January 23, 1996, to obtain additional information on the Syracuse and Hackensack fires. J. Gordon Routley was interviewed over the telephone on January 24, 1996, in regards to the many investigations he has conducted into firefighter deaths for the USFA.

Two survey instruments were developed. The first survey instrument, called the "Questionnaire to Chiefs, Captains and Lieutenants" (see Appendix A), was given to all 126 officers of the Providence Fire Department. The purpose of this survey was to aid in determining if the radio communication system in use in the Providence Fire Department was operationally adequate. Of the 126 surveys, 100 (79 percent) were completed and returned.

The second survey instrument, which was called the "Radio Communications Survey," was designed to examine the experience of other fire departments across the

country in regards to radio communications systems (see Appendix B). A number of specific questions were posed, including: whether the fire department operated on a single radio channel or multiple channels; whether any unmonitored channels were used; what precautions were taken when using unmonitored channels; and whether the department ever experienced a firefighter casualty either as a result of a radio channel being too busy, or due to the lack of monitoring by dispatch personnel.

Survey answers were cross referenced by demographic information about the fire department (population served, geographic area, paid, combination or volunteer) as well as activity level, as measured by the annual number of responses.

Both survey instruments were field tested on small groups, and improvements made prior to actual distribution. The "Radio Communications Survey" was given to 21 students in the *Executive Planning* class at the NFA between October 2 and October 13, 1995. It was also mailed out to fire departments listed on the NFA's Metropolitan Fire Department list, and fire departments in the metropolitan Providence, Rhode Island, and Boston, Massachusetts, areas. A total of 224 surveys were handed or mailed out; 158 surveys (70.5 percent) were completed and returned, including responses from all but three states, Delaware, Indiana, and Utah. Further demographic information about the responding departments is provided in Appendix C.

The data from both surveys were entered into a relational database (Paradox 4.5) and analyzed. The results were then tabulated and entered into a computerized spreadsheet (Quattro Pro 5.0 for Windows) and used to help answer the research questions.

Limitations

This research was limited by a number of factors and assumptions. The first assumption was that all surveys would be answered honestly by persons with enough knowledge to complete them. This assumption appears to have been flawed. On the "Radio Communications Survey," three fire departments with documented cases of communications-related fatalities responded that their department had not sustained a communications-related injury or fatality. This situation calls into question the appropriateness of using a survey instrument to gather information which may be sensitive in nature to the departments involved.

Furthermore, fire departments that have sustained recent line-of-duty deaths may be involved in litigation, under threat of litigation, or otherwise be disinclined to respond to surveys that would involve the incident. The result in terms of survey responses would be a numerical bias in favor of departments who have not sustained a recent fatality.

The population sampled by the "Radio Communications Survey" was by no means a representative sample of the fire service in the United States. It was numerically biased in favor of paid, professional fire departments from metropolitan areas.

In hindsight, the "Radio Communications Survey" instrument was flawed because it asked about communications-related casualties, and for information about the existing radio system in each fire department. However, it did not ask whether the existing radio system was in place when the communications-related casualties occurred. It was therefore not possible to draw comparisons and conclusions about the radio systems being used by fire departments that reported a communications-related casualty, since it was not clear what system was in place at the time the casualties occurred.

The author was limited during the literature review in identifying documented cases of firefighter deaths and injuries where communications was a contributing factor. This limitation occurred because most articles and reports on firefighter deaths and injuries focused on the more obvious causes of death, such as roof collapse, asphyxiation, disorientation, accountability, falls, etc. Communications-related problems were often ignored, or mentioned as a footnote (Demers, 1978).

According to Kathy Gerstner (personal communication, October 4, 1995), who tracks firefighter fatalities at the USFA, the USFA does not track all of the factors that contribute to a firefighter's death. Rather, the USFA tracks only the principle cause of death, such as heart attack, falls, smoke inhalation, or building collapse. The absence of contributing factor information was another limitation upon the author's ability to identify communications-related fatalities.

Definitions

CHANNEL The term "channel" as used in this research refers to a setting on a radio, regardless of whether or not the "channel" is simplex, duplex or trunked.

SIMPLEX The term "simplex" as used in this research refers to a radio channel that uses a single radio frequency to both broadcast and receive.

DUPLEX The term "duplex" as used in this research refers to a radio channel that uses two separate radio frequencies, one to transmit, and the other to receive.

REPEATER A repeater consists, at a minimum, of a radio receiver and a transmitter. A radio signal is received on one frequency by the receiver, and then rebroadcast over a new frequency, usually at much increased strength. A number of receivers can be located throughout a geographic area to ensure that a radio transmission made anywhere within the area will be able to reach at least one receiver. Repeaters are used with duplex radio systems to increase the range of portable and mobile radios.

TRUNKED A trunked radio system is a complex communications system that functions more like a wireless telephone system than a traditional radio system. With a trunked system, a channel setting on a radio does not correspond directly to particular radio frequency. Rather, each channel setting is referred to as a "talk group." Persons with radios set on the same "talk group" are able to communicate with each other. When

a user wishes to send a message over the radio, the system automatically selects which frequency the particular message will be transmitted on. The architecture of the system ensures that listeners on the same talk group will then receive the message, regardless of which radio frequency is actually used to transmit the message (McMillian, 1991).

RESULTS

1. Is the existing single radio channel used by the Providence Fire Department adequate given the volume of radio traffic that the system is expected to handle?

According to Chapter 16-5.3 of NFPA 1201, "Sufficient radio frequencies shall be provided to accommodate the operational needs of the fire department...based upon the amount of radio traffic that is anticipated...." (NFPA 1201, 1994, p. 17).

Chapter 3-4.1.5 of NFPA 1221 requires that dispatch channels be separate from channels used for routine or fireground communications (NFPA 1221, 1994, p. 19). Chapter 6-3.3 goes even further, requiring fire departments with over 2,500 alarms per year to provide a separate fireground radio communications channel (NFPA 1221, 1994, p. 20).

The Providence Fire Department routinely responds to over 36,000 incidents annually, using a single radio channel for both dispatch and fireground communications. Thus, the existing radio system in use by the Providence Fire Department does not comply with NFPA requirements regarding the need for multiple radio channels.

The survey of Providence Fire Department officers indicated that 65 percent (65 out of 100) believed the existing single-channel radio system was not meeting their needs. (See Table 1 and Figure 1.) Seventy-eight percent reported that they have had to wait to transmit a critical radio message while the radio was tied up with radio traffic not related to the incident they were at. (See Table 2 and Figure 2.) The term "critical" was defined as when lives were in jeopardy, or potentially in jeopardy. Fifty-seven percent reported that the inability to transmit a critical radio message occurred to them personally more than once or twice a year. (See Figure 3.) A full 94 percent of officers believed the use of additional radio channels will improve communications, with the remaining 6 percent reporting that additional channels will neither improve nor hamper communications. (See Table 3 and Figure 4.)

The Radio Communications Survey indicated that 147 of 158 fire departments surveyed, or 93 percent, use multiple radio channels. (See Table 4.) In fact, every fire department that responded to the survey that handled more than 12,000 incidents annually, used multiple radio channels. Also, all surveyed departments that protect a population larger than 100,000, reported using multiple channels.

The literature review into communications-related deaths and injuries disclosed that in the aftermath of the Hackensack fire, investigators cited the fact that the single radio channel was overwhelmed with traffic as a major contributing factor to the firefighter deaths (Demers, 1988). A similar conclusion was drawn after the East Bay Hills fire in Oakland, California (Routley, 1991a).

Table 1

Providence Fire Department Questionnaire

1. Is the present radio system meeting your needs?	Yes	27
	No	65
	Not Sure	8

Figure 1

Is the present radio system meeting your needs?

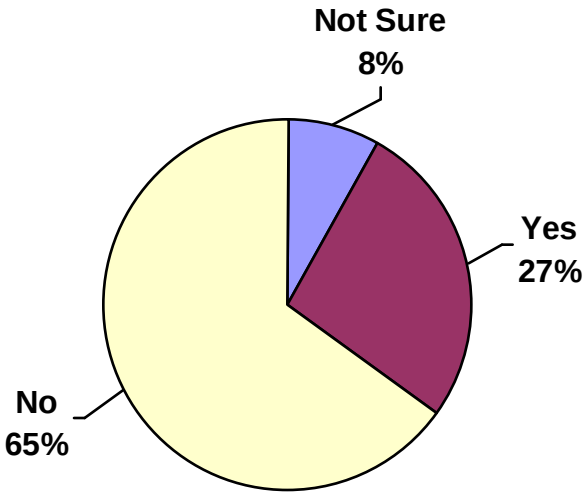

Table 2

Providence Fire Department Questionnaire

2. Have you ever had to wait to transmit a critical message due to radio traffic not related to the incident you were at?		Yes	78
		No	22
How frequently?	3	Very Infrequent (<1 time in 5 years)	
	18	Infrequent (once in 1 to 5 years)	
	36	Occasionally (1 or 2 per year)	
	13	Frequently (3 to 6 per year)	
	8	Very Frequently (<6 times per year)	

Figure 2

Have you ever had to wait to transmit a critical message?

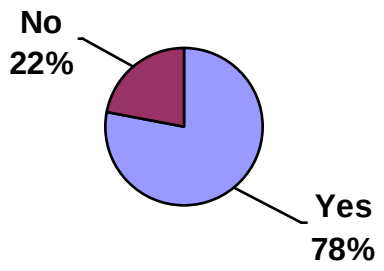

Figure 3

How frequently are critical messages being delayed?

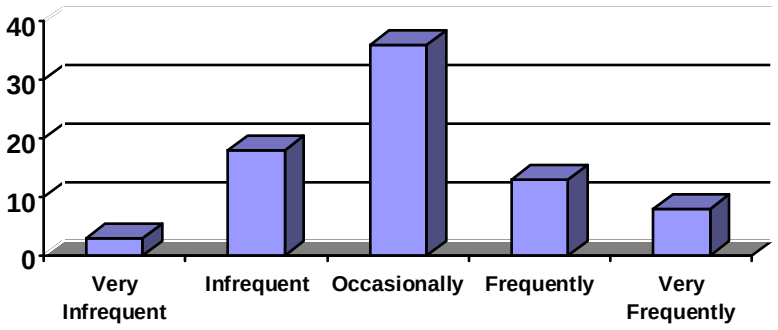

Table 3

Providence Fire Department Questionnaire

3. The use of additional radio channels will	94	Improve Communications
	0	Hamper Communications
	6	Neither

RESPONSES				YEARS OF EXPERIENCE	
Chiefs	12	Fire	89	5-10	3
Captains	20	Rescue	9	10-15	19
Lieutenant	68	Staff	2	15-20	48
Total	100			Over 20	30

Figure 4

Will the use of additional radio channels improve/hamper communications?

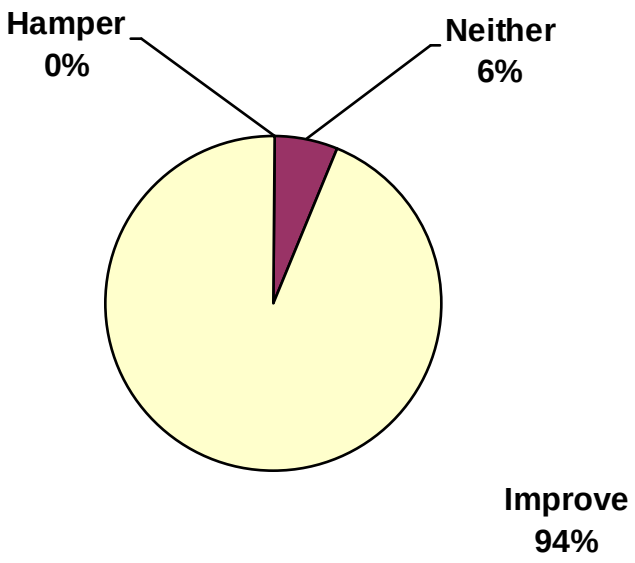

Table 4

Radio Communications Survey

	Under 25,000	25,000 to 99,999	100,000 to 249,999	250,000 to 500,000	Over 500,000	Totals
FDs Responding	20	49	28	28	33	158
Use Multiple Channels	17	41	28	28	33	147
Monitor All Channels	13	25	20	20	19	97
Use Unmonitored Channels	4	16	8	8	14	50
Channel Overloading Casualty	0	2	3	0	3	8
Unmonitored Channel Casuality	0	0	0	0	1	1

Surveys sent/handed out	224
Surveys returned	158

In light of all these factors, the current radio system in use by the Providence Fire Department is not adequate to handle the volume of radio traffic that it is expected to handle.

2. Are there documented cases of firefighters being killed or injured where the fact that radio channels were too busy with other traffic was found to be a contributing factor?

The Radio Communications Survey found that eight fire departments, or 5 percent, experienced communications-related casualties where the fact that radio channels were too busy with other radio traffic was found to be a contributing factor. (See Table 4.) In addition, two surveys reported that such problems had occurred in neighboring fire departments.

The literature review disclosed two documented cases where overloading problems occurred, with Hackensack being the most prominent. Demers (1988), cited the fact that the single radio channel in Hackensack was overwhelmed with radio traffic as a contributing factor in the deaths of at least two of the five firefighters. Competition for "air time" had a "significant impact on communications with the trapped firefighters" (Demers, 1988, p. 15). This competition was both incident-related (other fireground communications) and non-incident related (dispatching, recall of off-duty personnel, and emergency medical responses).

The East Bay Hills fire in Oakland, California, was another example where the use of a single radio channel was overwhelmed by the volume of radio traffic (Routley, 1991a).

3. Are there documented cases of firefighters being killed or injured where the lack of monitoring of the radio channel by dispatch personnel was found to be a contributing factor?

The Radio Communications Survey disclosed only one fire department, or .6 percent, that reported sustaining a firefighter casualty relating to the lack of monitoring by dispatch personnel. (See Table 4.) However, the validity of these results is in question due to the fact that three fire departments with documented cases of communications-related casualties (firefighters in distress calling for help on unmonitored or overloaded radio channels) in the literature, reported on their surveys that they had never sustained such a casualty.

The literature review disclosed several cases where the lack of monitoring of radio channels by dispatchers contributed to firefighter casualties. The Syracuse incident investigated by Demers (1978), was one example. The Hackensack fire (Demers, 1988), the Memphis church fire (Smith, 1993), the Regis Tower fire in Memphis (Chubb & Caldwell, 1994), and the Blackstock Lumber Company fire in Seattle (Isner, 1990), are other examples where firefighters operating on unmonitored radio channels attempted to use their radios to call for assistance without success. While there may have been other

communications-related issues involved in each of the above-referenced cases, had a trained dispatcher been monitoring the channel that the members were broadcasting on, and had the radio system been designed to facilitate such monitoring, emergency assistance could have been provided sooner to firefighters in distress.

4. Do most fire departments that use multiple radio channels have dispatchers monitor all fireground channels that are being used?

The Radio Communications Survey indicated that 147 of 158 fire departments surveyed, or 93 percent, use multiple radio channels. (See Table 4.) Of these, 97 out of 147, or 66 percent, require that dispatch personnel monitor fireground channels whenever they are in use. Some variation was noted among fire departments by population served, with 76.5 percent of departments (13 out of 17) serving under 25,000 monitoring all channels, while only 58 percent (19 out of 33) of departments with populations of over 500,000 did so. (See Table 4.) Among cities the size of Providence (100,000 to 249,999), 71.4 percent of fire departments (20 out of 28) monitor all radio channels in use.

Thus, most fire departments that use multiple radio channels, have dispatchers monitor all fireground channels that are being used.

5. What procedures do fire departments that use unmonitored fireground tactical channels use so that critical messages (particularly "Mayday" messages or building evacuation orders) are properly transmitted, received, acknowledged and acted upon?

The Radio Communications Survey showed that there are a number of procedures used by fire departments that operate unmonitored fireground radio channels, to ensure that critical messages are properly transmitted, received, acknowledged and acted upon. The most common procedure noted by all 50 survey responders that use unmonitored fireground channels, was to have the IC monitor and coordinate radio traffic on the fireground channel.

Twelve of the 50 fire departments (24 percent) reported that their ICs monitor two channels, the fireground channel and the dispatch channel. (See Table 5.) When necessary, the IC is required to call over the dispatch channel to request a dispatcher to make building evacuation orders or to declare emergency traffic on the fireground channel. The dispatcher would then broadcast the requested message over the fireground channel.

Ten fire departments (20 percent) reported using auxiliary personnel on the fireground to assist the IC in monitoring and controlling fireground radio traffic. Four departments reported that they use a chief's aide for this purpose. Three departments reported that they use safety officers and three reported that other auxiliary personnel, termed "communications officers," "communications coordinators," or "radio aides," are used.

Table 5

Alternatives Used by Fire Departments Operating Unmonitored Fireground Channels

	Under 25,000	25,000 to 99,999	100,000 to 249,999	250,000 to 500,000	Over 500,000	Totals
Total FDs	4	16	8	8	14	50
IC Monitors 2 Channels	0	4	2	2	4	12
Auxiliary Personnel On-Scene	1	2	3	1	3	10
Aide	0	0	1	1	2	4
Safety Officer	1	1	1	0	0	3
Other	0	1	1	0	1	3
Emergency-Distress Alarm	0	1	1	1	2	5
FF switches to dispatch channel	0	1	1	1	1	4
Emergency Traffic Signal Broadcast over all channels	0	1	0	1	1	3
IC Monitors without backup or use of Emergency-Distress Alarms	3	13	4	6	9	35

Note: Some fire departments may use more than one precaution. For example, a fire department may use an Emergency-Distress Alarm as well as a Safety Officer to monitor the radio.

Five departments (10 percent) reported that they use "emergency-distress alarms" built into portable radios as a means of ensuring that critical messages are not missed. These alarms are tied to a radio identifier system that, when activated, notifies the dispatch office of exactly which radio is in alarm. The dispatch office can in turn identify which company the radio is assigned to, and notify the appropriate IC that the company has activated their emergency alarm.

Four departments (8 percent) reported that they have operational procedures that require personnel in distress at an incident scene to switch to the main dispatch channel and declare their emergency directly to the dispatch office.

Three departments (6 percent) reported that "Emergency Traffic" and/or "building evacuation" type announcements are broadcast over all radio channels by the dispatch office. Such a procedure requires an IC to contact the dispatch office over the dispatch channel.

DISCUSSION

Effective communication has always been an important component of successful fireground operations. However, the modern fire service has come to depend heavily upon radio communications, so much so that efficient operations as well as firefighter safety now depend to a great extent on how well our radio communications systems function.

The radio communication system used by the Providence Fire Department has historically had an excellent record. Since its inception, the single-channel radio system provided the department with good, reliable service. The under-recognized role played by the dispatcher has been critical to the success of the overall system.

The dispatcher's function within the system has been to dispatch apparatus, maintain control and discipline on the air, receive and forward messages, prioritize messages from several units all desiring to speak at the same time, and otherwise to manage the radio network.

As the system has evolved, the role of the dispatcher has evolved, to a point where the dispatcher essentially functioned as a "backup" to the IC during fireground operations. When an IC attempted to contact a unit, and the unit did not answer, the dispatcher's role was to step in and contact that unit for the IC. When a unit attempted to contact the IC, again the dispatcher was available to ensure that the message was received and acknowledged.

The critical importance of the role of a dispatcher as an "insurer" that fireground messages are received, is evident by looking at incidents such as Syracuse, Hackensack, Blackstock Lumber, and Regis Tower fires. At these incidents, firefighters in distress

attempted to use their portable radios to call for help, but for varying reasons the respective ICs were not aware of the firefighters' peril until it was too late.

The assistance that dispatchers in Providence were able to provide to ICs operating at incident scenes, went beyond monitoring the channel for distress messages and facilitating message transfers. Dispatchers routinely transmitted emergency notifications and messages, made building evacuation announcements, and conducted emergency roll calls to account for the safety and location of operating units. Each of these roles played by the dispatcher served to ease the burden on the IC, and improve firefighter safety.

The use of the dispatcher as the IC's "backup" may have been almost inadvertent at first, as an outgrowth of the fact that fireground operations were taking place on the same channel being used for dispatch. However, it soon became apparent that the role the dispatcher could play during fireground operations was a major advantage of having all radio communications on one channel that was monitored. In fact, many of the radio communications problems that occurred in other jurisdictions were unlikely to happen in Providence because of the role that the dispatcher played within the system.

As the Providence Fire Department's use of, and reliance upon, radio communications grew, so did the volume of radio traffic. This research project clearly shows that there is a need for the present radio system to be upgraded to a multiple-channel radio system.

The NFPA standards call for separate dispatch and fireground channels for systems the size of Providence's. The collective experience of the officers of the Providence Fire Department was that the single-channel system was not meeting their needs. Probably most disconcerting was the fact that 78 percent of officers reported having had to wait to transmit a critical message due to radio traffic not related to the incident they were at. This factor alone is a clear indication that the system is dangerously overloaded.

The peril of an overloaded radio system was evident in both the Hackensack and East Bay Hills fires. Demers cited Hackensack's one channel system as being "totally inadequate" (Demers, 1988, p. 15), and a contributing factor in at least two of the fatalities. According to J. Gordon Routley (personal communication, January 24, 1996), the Oakland radio channel at the East Bay Hills fire was "absolutely overloaded, so much so that no effective communications could take place."

It is important to recognize that there are two categories of messages that contribute to radio system overloading. The first category is incident-related messages, messages that pertain directly to the incident at which companies are operating. The second category is messages that are not related to the incident. These include dispatching, routine radio traffic and other incidents taking place simultaneously with the incident of focus.

In general, the overloading of a radio channel due to non-incident-related messages can be addressed through the use of additional radio channels. However, overloading due to incident-related messages is, in large measure, a matter of effective radio discipline. Overloading due to incident-related messages will not be solved merely by resorting to an additional fireground channel. In fact, the research shows there are valid safety reasons why multiple fireground channels should not be used at the same incident.

A case in point was the Brackenridge, Pennsylvania, fire (Routley, 1991b), where the deaths of four firefighters were attributed in part to the fact that they were operating on a separate radio channel and did not hear progress reports on the main channel that warned of worsening fire conditions.

Another case was the Pittsburgh fire (Routley, 1995), where the use of different radio channels by fire and emergency medical personnel contributed to confusion over who was missing and who was rescued. The confusion led to the erroneous conclusion that all firefighters had been accounted for, when in fact three firefighters were missing in the building. As a result, no effort was made to initiate a search for downed firefighters.

Undoubtedly, at major incidents such as the East Bay Hills fire, it may be necessary to sectorize an incident and use multiple fireground channels. However, such incidents are really the exception to the rule. Generally, all units at the scene need to be able to communicate with each other (BLM, 1995; Rosato, 1991; Routley, 1991b, 1993, 1995), and the easiest way to accomplish this is to ensure that all tactical operations at an incident take place on the same channel.

Without proper radio discipline, fireground channels can become overloaded with incident-related traffic just as easily as combined dispatch/fireground channels. This, in fact, occurred in Detroit during a warehouse fire that claimed the lives of three Detroit firefighters in 1987 (J.A. Reardon, personal communication, December 13, 1995). According to Mr. Reardon, communications on the fireground channel (which was not monitored by dispatchers) were so numerous that it was impossible for the command post to communicate with various sector officers for an extended period of time. While the communication problem at the Detroit warehouse fire had no bearing on the firefighter deaths, it did create logistical problems that could have had disastrous consequences under the right set of circumstances (J.A. Reardon, personal communication, December 13, 1995).

Problems with overloading due to incident-related radio traffic must be solved by effective radio communication procedures and discipline. The Hackensack fire is a good example. The New Jersey Bureau of Fire Safety (1989), cited the fact that 50 percent of the messages transmitted at the Hackensack fire were never acknowledged. Besides the obvious safety implications of an unacknowledged message, the result of an unacknowledged message is often that the message has to again be repeated, further contributing to unnecessary radio traffic.

Besides unacknowledged messages, units at the Hackensack fire routinely transmitted over one another, with more powerful mobile radios overriding less powerful portable radios (Demers, 1988). Demers simplified the critical radio problem in Hackensack to one poignant point: "There was a whole lot of talking, but very little communicating going on" (D.P. Demers, personal communication, January 23, 1996).

In this respect, Providence has indeed been fortunate. By using a single-channel system that was monitored by dispatchers, control and discipline of the radio network has been maintained. The role of the dispatcher within such a system can be likened to that of a "traffic cop," managing the communications intersection to keep the traffic flowing in an orderly fashion, and preventing gridlock.

The research showed that the failure to have dispatch personnel monitor channels being used for fireground operations in other jurisdictions has contributed to firefighter casualties (Demers, 1978; Klem, 1988). The Syracuse fire (Demers, 1978), was the first reported case where civilians with scanners heard firefighters in distress calling for help over the radio, but the IC and dispatchers did not. There have been strikingly similar occurrences in both Hackensack (Demers, 1988), and Seattle (Isner, 1990).

Requiring that dispatchers monitor all radio channels that are being used is only part of the equation. The radio system's hardware must facilitate monitoring. This usually requires the use of a duplex channel with an adequate number of receivers/repeaters to ensure that portable radios will be heard at the dispatch office. The use of a simplex channel was an issue in the Syracuse fire (D.P. Demers, personal communication, January 23, 1996), and at the Blackstock Lumber fire in Seattle (Isner, 1990), where portable radios simply could not reach the dispatch office on the channel being used.

Furthermore, dispatchers must be trained in what to do when they receive a message such as a firefighter in distress. The Regis Tower fire in Memphis was an example of a dispatcher hearing an urgent message from a firefighter obviously in distress, but taking no action in response (R. Arwood, personal communication, October 31, 1995). According to Demers (personal communication, January 23, 1996), a similar problem occurred in Hackensack. As far as the life safety of firefighters is concerned, having a dispatcher hear an urgent request for help from a firefighter in distress, and fail to take appropriate action, is the functional equivalent of having an unmonitored channel. Said in another way, a radio channel is not being effectively monitored if the dispatcher either cannot hear a critical distress message, or hears the message but does nothing.

The research showed that 93 percent of all fire departments surveyed operate on multiple channels. Perhaps even more significantly, every fire department surveyed that protects a population of more than 100,000 persons, or responds to more than 12,000 incidents annually, uses multiple channels.

Of fire departments that operate on multiple channels, 66 percent require that fireground channels be monitored by dispatch personnel whenever in use. For

communities the size of Providence (population of 100,000 to 249,999), 71.4 percent require that the fireground channels be monitored by dispatch personnel when in use. Thus, the clear majority of fire departments surveyed use multiple-channel radio systems, and require dispatchers to monitor fireground channels when in use.

However, the use of multiple radio channels should not be viewed as a panacea for solving communication problems in general, nor overloading problems in particular. The use of multiple channels brings with it a whole host of new communication problems that can create additional risks to personnel (Chubb & Caldwell, 1994; Isner, 1990; Routley, 1991b, 1995).

At both the Regis Tower fire (Chubb & Caldwell, 1994), and the Blackstock Lumber fire (Isner, 1990), part of the communication problems involved the fact that firefighters were transmitting distress messages on the wrong channel. At the East Bay Hills fire, critical information was missed while command personnel switched off the main channel and were talking on a backup channel. In Pittsburgh and Brackenridge the fact that onscene personnel at the same incident were communicating on more than one channel contributed to firefighter fatalities (Routley, 1991b, 1995). Thus, the use of multiple radio channels is not a risk-free proposition.

The literature review disclosed that there are no NFPA standards that require fireground channels to be monitored by a dispatcher. NFPA 1561, Chapter 3-6.5, required that dispatchers "provide support to" emergency incident personnel, and that dispatchers be "trained to function effectively within the incident management system" (NFPA 1561, 1990, p. 8). The phrase "provide support to" was not further defined in the standard. However, the argument can be made that it is impossible for a dispatcher to "provide support to" units working at the scene on an emergency if he or she is not monitoring the channel that the onscene units are using.

Of the minority of fire departments that do not have dispatchers monitor their fireground channels when in use, 70 percent (35 out of 50) reported that they take no precautions whatsoever to avoid critical messages being missed, other than expecting the IC to monitor the fireground channel.

The drawback of relying solely upon an IC to monitor a fireground channel, is that there are a multitude of factors at the scene of an emergency that are competing for the attention of the IC. Command decisions must be made, face-to-face and cellular telephone communications take place, reference materials must be checked, accountability documentation prepared, and physical observations of conditions and firefighting activities must be made. All of these occur under ambient noise and stress levels that are less than ideal for listening to a radio.

The literature review disclosed numerous cases where reliance upon the IC to hear critical distress messages resulted in messages being missed. Whether we consider Syracuse, Hackensack, Blackstock Lumber, or Regis Tower, ICs did not hear urgent distress calls from firefighters whose lives hung in the balance. Given the multitude of

factors affecting an IC at an emergency scene, it simply is unrealistic to expect that they can effectively monitor fireground channels without assistance or backup.

This problem is complicated even further in those jurisdictions where ICs are required to monitor two channels, the fireground channel and the dispatch channel. At the Regis Tower fire (Chubb & Caldwell, 1994), the IC was monitoring the fireground channel on his portable radio, and monitoring the dispatch channel on his vehicle's radio. When a firefighter in distress inadvertently transmitted a message over the dispatch channel, the IC was momentarily away from his vehicle, and thus the message was missed. The firefighter in distress was one of two firefighters who ultimately died at the fire.

In the aftermath of the Regis Tower fire, the Chief of Training for the Memphis Fire Department, Richard B. Arwood, investigated the practicality of requiring an IC to monitor two channels (personal communication, October 31, 1995). Chief Arwood concluded that "It is physically impossible for anyone to monitor two channels at the same time, let alone an incident commander at the scene of an emergency." Chief Arwood stated he has proven this fact repeatedly in field tests.

The Radio Communications Survey indicated that 10 fire departments, or 20 percent of those who do not require dispatchers to monitor fireground channels, use onscene support personnel to assist the IC with monitoring responsibilities. Four departments reported that they used the chief's aide for this purpose, while three others reported that they use the Safety Officer.

However, both chief's aides and Safety Officers have other critical duties to perform at incident scenes. While such a procedure provides some level of redundancy that may lessen the risk that a critical distress message will be missed completely, it will do nothing to help maintain control and discipline over the radio channel, nor ensure that emergency notifications and building evacuation orders are made clearly and acknowledged.

Three departments reported that they designate specific auxiliary personnel at incident scenes to monitor and control fireground radio traffic. The names given to such personnel include "communications officers," "communications coordinators," and "radio aides," but the roles as described, are the functional equivalent of having a dispatcher at the incident scene to coordinate all onscene communications. They provide the necessary redundancy in the system to ensure that critical messages are not missed, and at the same time fulfill the vital "traffic cop" role.

The principal drawback to having an onscene person coordinating fireground communications is the likelihood of a lapse between the arrival of first-in units, and the arrival of the communications person. The first few minutes at the scene of an emergency are often the most hectic. During this initial period, the communications person will likely still be responding, or may be busy setting up a communications

command post. Without a dispatcher monitoring the fireground channel during the initial phase, the onscene companies will be operating on an essentially unmonitored channel.

Five fire departments that operate unmonitored fireground channels reported that they use emergency-distress alarms built into their portable radios as a means of ensuring that critical messages are not missed. These alarms address the most critical communication problem created by using multiple channels, that of ensuring that an emergency message from a firefighter in distress is received.

However, emergency-distress alarms do not offer a complete solution to the communications problems created by using multiple channels. They do nothing to help maintain control of the radio channel, where units may be "talking over" one another and competing for "air time." Emergency-distress alarms do not ensure that emergency notifications or building evacuation orders will be made clearly and received by all units.

In the aftermath of the Indianapolis Athletic Club fire, there are significant questions about the accessibility of portable radios to activate an emergency-distress alarm. As presently designed, activation of the alarm requires the firefighter to remove a glove and depress a small button on the radio. Depending upon where the radio is worn, it may also require that the protective coat be opened or pulled up in order to reach the radio. This can lead to firefighter injuries as well as the inability in certain cases of firefighters to be able to activate the alarm. Thus, while emergency-distress alarms are of some value, they are not a total solution to the communications problems associated with multichannel operations.

Four fire departments reported that their operational procedures require that firefighters in distress switch from the fireground channel to the dispatch channel to declare their emergency on a monitored channel. Such a procedure is subject to a number of limitations. First of all, changing channels may require a firefighter to compromise the integrity of his or her protective clothing to access the channel selector switch, and change channels. Secondly, such a change would be taking place under extremely stressful conditions, increasing the likelihood that the radio may be set to the wrong channel. Thirdly, such a procedure does not address the issue of maintaining control and discipline on the fireground channel.

In summary, a multiple-channel radio system holds the key to reducing the risk of radio channel overload for the Providence Fire Department. Having a dispatcher monitor and coordinate communications on a fireground channel provides a critical level of safety for operating forces. None of the alternatives to monitoring a fireground channel by dispatch personnel appears adequate, with the possible exception of assigning onscene personnel to manage fireground radio communications. All other solutions have shortcomings that result in firefighter safety being compromised. None can adequately ensure that critical messages will be heard and acknowledged the way that a dispatcher monitoring the radio channel can. Furthermore, none provide the additional benefit of having a "traffic cop" to make sure communications remain orderly and under control.

RECOMMENDATIONS

The Providence Fire Department and the Providence Department of Communications should implement a multichannel radio communications system as quickly as possible. The present single-channel system is overloaded, and the use of a multichannel system offers to significantly improve radio communications.

The fire and communications departments should ensure that a dispatcher is assigned to monitor and manage radio communications on the proposed fireground channels whenever they are in use. Once command is established at a fire or other emergency, all communications between BOC and the incident scene should take place over the fireground channel. This procedure will provide a minimum level of safety for operating personnel, and will eliminate the need for command personnel to use the dispatch channel to request additional resources, which in turn would require command to have to monitor multiple channels.

A comprehensive communications SOP should be developed jointly between the fire department and the communications department to address the various issues involved in multichannel operations. Personnel from both departments should be used to research, develop, and write this SOP.

All dispatch personnel, as well as all line firefighters, need to be trained in the specific operational procedures to be used with the multichannel system, as well as their respective responsibilities. One of the lessons learned from the Indianapolis Athletic Club fire was the importance of training and familiarity with a radio communications system before it is put into use (Chubb, 1992).

Procedures and training should emphasize the need for dispatchers to take a proactive role in managing radio communications. Passive monitoring of the radio channel is not enough to prevent congestion and overloading. Overloading problems are not limited to dispatch channels, and will occur on fireground channels if proper radio discipline is not enforced. Dispatcher training should specifically address maintaining discipline and control of the radio channel when multiple units wish to communicate at the same time under emergency conditions, as well as proper response to urgent messages from firefighters in distress.

Additional research is recommended to determine the optimal staffing level at BOC to ensure that all of the various communications-related functions can be handled in accordance with NFPA standards.

The only feasible alternative to having a dispatcher monitor the fireground channels is to provide an onscene communications officer to control and manage fireground communications. The individuals selected to fulfill this vital role will require specialized training and some level of authority.

The use of a chief's aide or a Safety Officer to fulfill the role of an onscene communications officer is not recommended, since each of these positions already have specific and essential responsibilities to fulfill at emergency scenes that are incompatible with those of a communications officer. The Fire Department of the City of New York uses a Battalion Chief to fulfill the role of "Communications Coordinator" (Manual of Fire Communications, 1995). If the fire and communications departments opt to rely upon an onscene communications officer, further research into New York City's experience is strongly recommended.

All onduty firefighters in Providence should be issued a portable radio with an emergency-distress alarm option. This radio should be considered part of the firefighters' mandatory personal protective equipment (PPE), just as are self-contained breathing apparatus (SCBA) and a personal alert safety system (PASS) device.

The purpose of issuing a portable radio to each firefighter is not to facilitate routine communications, but solely for use in the event of an emergency. The importance of a radio to a firefighter in distress cannot be overemphasized. A cursory examination of the literature review shows just how valuable a portable radio can be to a firefighter in distress.

All protective coats in the Providence Fire Department should be retrofitted with an exterior pocket designed specifically to accommodate portable radios. A radio pocket will eliminate the need for firefighters to wear the radio on the inside of their protective clothing, and will make the channel selector switch and emergency-distress alarm more accessible. This, in turn, will minimize the need for firefighters to compromise their protective clothing in order to access portable radios to change channels or activate the emergency-distress alarm.

Additional research is needed into the relationship between firefighter safety and radio communications. The literature review revealed a total lack of research into the nexus of firefighter safety and radio communications. Only one journal article was found that even remotely addressed the subject (Furey, 1990). Two books were found on radio communications issues in the fire service, but neither focused upon the firefighter safety aspect of radio communications (Holt, 1991, Spahn, 1989). In addition, many of the leading books on firefighter safety gave little or no mention of the critical role that radio communications play in modern firefighter safety (Brunacini, 1985; Dunn, 1992; International Fire Service Training Association, 1991; Norman, 1991).

Additional research is needed to focus specific attention on the communications-related aspects of firefighter fatalities. All too often, the most obvious causes of firefighter fatalities get the attention of investigators, while the more subtle contributing factors are ignored. In this regard, it is recommended that the USFA begin tracking all contributing factors associated with a firefighter fatality, as opposed to merely the primary cause of death.

Additional research is needed to develop a portable radio specifically for the fire service. The existing portable radios have a number of limitations. Most are not waterproof, nor can they be easily retrofitted to be waterproof. This fact makes it necessary for the radio to be protected from our primary tool in extinguishing fires: water. Inaccessibility problems result, as radios must be concealed underneath protective clothing. Features such as the volume switch, channel selector, and emergency-distress alarm, even when accessible, are difficult to operate with a gloved hand.

According to J. Gordon Routley (personal communication, January 24, 1996), radio manufacturers have concluded that it is not financially worth the cost of researching, developing, and manufacturing a portable radio specifically for the fire service. That being the case, it is recommended that the USFA underwrite a research project to develop a design for an affordable portable radio specifically for the fire service.

Additional research is recommended to investigate whether NFPA standards should include a requirement that fireground channels be monitored by a dispatcher, or at least by someone in addition to the IC. The NFPA should also consider amending NFPA 1201 to include a requirement that portable radios be issued to all firefighters, not just chiefs and company officers, as a matter of firefighter safety.

The above recommendations are made humbly and respectfully, ever mindful of the advice of Frank Holt: "Just as no two emergency communications are the same, there's no foolproof plan for success in managing your emergency communications system--only a fool would suggest that such a plan were possible" (Holt, 1991, p. xv).

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APPENDIX A

PROVIDENCE FIRE DEPARTMENT

Questionnaire to Chiefs, Captains and Lieutenants

The following questionnaire pertains to the present radio system in use by the Providence Fire Department. Please answer the following questions from your own personal experience. Please do not rely on events or experiences that happened to others in answering these questions.

1. Is our present radio system meeting your needs.

   _____ Yes
   _____ No
   _____ Not Sure

2. Have your ever had to wait to transmit a message at the scene of an emergency that you considered to be critical, while the radio was tied up with radio traffic not related to the incident that you were at? (For purposes of this question, assume the term critical means that lives were in jeopardy or potentially in jeopardy.)

   _____ Yes
   _____ No

   If you answered yes to question 2, then in your personal experience how frequently has such a problem occurred?

   _____ very infrequently (less than once every five years)
   _____ infrequently (once every one to five years)
   _____ occasionally (approximately once or twice a year)
   _____ frequently (3 to 6 times per year)
   _____ very frequently (more than 6 times per year)

3. Do you believe the use of additional radio channels would

   _____ improve communications
   _____ hamper communications
   _____ neither improve or hamper communications

4. Background.

   Rank: _____ Chief Officer
   _____ Captain
   _____ Lieutenant

   Division _____ Fire
   _____ Rescue
   _____ DOT/HQ/Staff

   Experience _____ 5 to 10 years (Total service on Dept.)
   _____ 10 to 15 years
   _____ 15 to 20 years
   _____ over 20 years

Department of Public Safety, Fire Department
"Building Pride In Providence"

VINCENT A. CIANCI, JR.
MAYOR
JOHN J. PARTINGTON
COMMISSIONER

R. MICHAEL DI MASCCLO
CHIEF OF DEPARTMENT
JOSEPH F. ERRICO
ASS'T. CHIEF OF DEPARTMENT

October 20, 1995

Dear Officer;

As part of a course I am taking at he National Fire Academy, I am conducting a research project. I would ask that you take a few moments to fill out the accompanying questionnaire that asks some questions about your experience and thoughts on our existing radio system. Please answer the questions from your own personal experience. The questionnaire is being given to all officers in the department.

Thank you for your time. If you would like a copy of the results, please contact me at

Respectfully;

J. Curtis Varone
Battalion Chief
3rd Battalion, Group A

Telephone (401) 421-1293 · 209 Fountain Street · Fax (401) 274 401)751 -0203
Providence, Rhode Island 02903

APPENDIX B

RADIO COMMUNICATIONS SURVEY

1. Please answer the following questions about your fire department.

Population served:
- under 25,000 _____
- 25,000 – 99,999 _____
- 100,000 – 249,999 _____
- 249,999 – 500,000 _____
- over 500,000 _____

Fully Paid _____
Combination _____
Fully Volunteer _____

Rural _____
Suburban _____
Urban _____

Geographic Location
- _____ Northeast CT, ME, MA, NH, NJ, NY, PA, RI, VT.
- _____ North Central IL, IN, IA, KS, MI, MN, MO, NE, ND, OH, SD, WI.
- _____ South AL, AR, DE, DC, FL, GA, KY, LA, MD, MS, NC, OK, SC, TN, TX, VA, WV.
- _____ West AK, AZ, CA, CO, HI, ID, MT, NV, NM, OR, UT, WA, WY.

2. How many total responses does your department handle annually? (Please include all fire department responses including fire department emergency medical responses if provided, hazmat, service calls, false alarms, etc.)

_____

IN ANSWERING THE FOLLOWING QUESTIONS, PLEASE ASSUME THE TERM "RADIO CHANNEL" REFERS TO A SETTING ON A RADIO, REGARDLESS OF WHETHER THE CHANNEL IS A SIMPLEX (SINGLE FREQUENCY) CHANNEL, DUPLEX (TWO FREQUENCY) CHANNEL OR TRUNKED SYSTEM. WHEN COUNTING THE NUMBER OF CHANNELS, DO NOT COUNT "TALK-AROUND" CHANNELS THAT ARE PART OF A DUPLEX CHANNEL THAT HAS ALREADY BEEN COUNTED.

3. Does your department utilize multiple radio channels? _____ (Yes or no)

4. If your answer to Question 3 was yes please answer the following:

   a. how many channels do you utilize in total? _____
   b. how many channels are used for dispatching apparatus? _____
   c. how many channels are used for fireground or tactical purposes? _____

5. Does your department utilize a separate "mutual aid" channel in addition to those listed above, in order to communicate with neighboring departments?
   _____ (Yes or no)
   If yes, how many mutual aid channels does your department use? _____

6. Are all of the radio channels used for dispatch, fireground, and tactical purposes, monitored continuously by dispatch personnel when being used?
   _____ (Yes or no)

7. If your answer to Question 6 was no:
   a. Please explain which radio channels are not monitored by dispatchers:

_____

_____

_____

   b. What steps (if any) does your department take to ensure that critical fireground messages (such as a "Mayday" message, or a building evacuation order), are properly transmitted, received, acknowledged and/or acted upon when using unmonitored channels?

_____

_____

_____

8. To the best of your knowledge, has your department ever had a firefighter killed or injured at an incident scene where the fact that the radio channel was too busy with other radio traffic was found to be a contributing factor?

9. To the best of your knowledge, has your department ever had a firefighter killed or injured at an incident scene where the lack of monitoring of the radio channel by dispatch personnel was found to be a contributing factor?

10. What type of radio system do you operate:

_____ UHF
_____ VHF
_____ 800 MHz trunked
_____ other trunked
_____ other

Please note that your department will not be identified by name in the research report. However, I ask your cooperation in providing your department's name so that duplicate responses from the same department can be prevented.

Department: _____

Contact person: _____

Telephone or E-mail: _____

Department of Public Safety, Fire Department
"Building Pride In Providence"

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COMMISSIONER

R. MICHAEL DI MASCCLO
CHIEF OF DEPARTMENT
JOSEPH F. ERRICO
ASS'T. CHIEF OF DEPARTMENT

October 31, 1995

Dear Chief;

The Providence Fire Department is in the process of upgrading our radio communications system. As part of a research project I am conducting for the Executive Planning course at the National Fire Academy, please find enclosed a "Radio Communications Survey".

I would ask that you or someone that you designate complete this survey, and return it to me at your earliest convenience in the pre -addressed, stamped envelope provided. The information gathered by the survey will be combined with information from other fire departments nationwide. Your department will not be identified by name or description. The compiled information will then be used to complete the research and help the Providence Fire Department plan how to improve its communications system. Thank you for your time and consideration. If you would like a copy of the complied information, please make a note of that fact on the survey form and include your name and address.

Very truly yours;
J. Curtis Varone
Battalion Chief

Telephone (401) 421-1293 · 209 Fountain Street · Fax (401) 2748508 · TDD # (401)751-0203
Providence, Rhode Island 02903

APPENDIX C

RADIO COMMUNICATIONS SURVEY

Demographics of Responding Fire Departments

Total Surveys Mailed 224
Total Surveys Returned 158 Response 70.54%

Population Served		Fire Department		Area	
Under 25,000	20				
25,000 to 99,999	49	Fully Paid	128	Urban	101
100,000 to 249,000	28	Combination	29	Suburban	43
250,000 to 499,000	28	Volunteer	3	Rural	11
Over 500,000	33				

Geographic		Responses	
Northeast	48	Under 2,500	24
North Central	27	2,501 to 10,000	43
South	42	10,001 to 20,000	17
West	38	20,001 to 50,000	27
		Over 50,000	32

Does your FD utilize Multiple Radio Channels?	Yes	147	93.04%
	No	11	
If your FD uses multiple channels, are all of your operational channels monitored when used?	Yes	97	65.99%
	No	50	